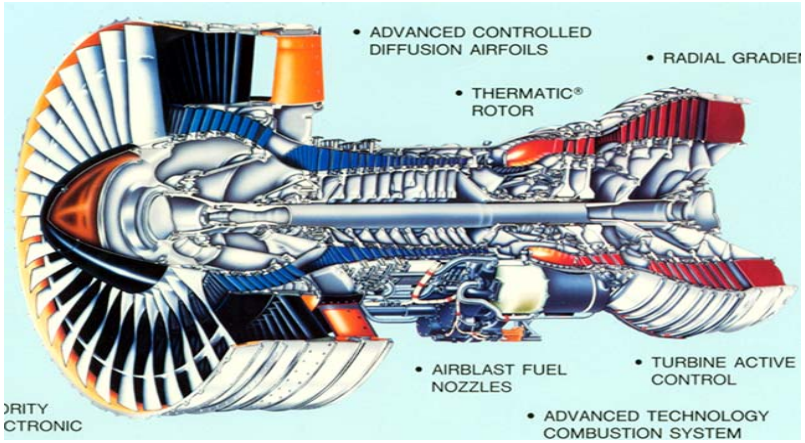
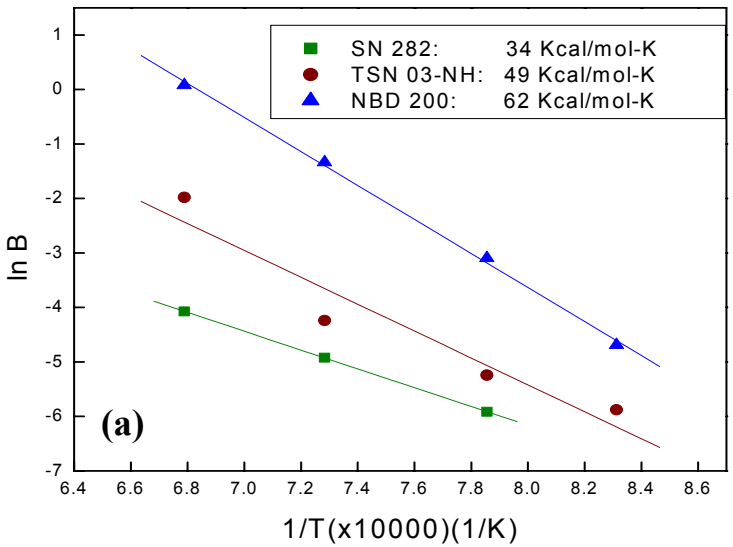
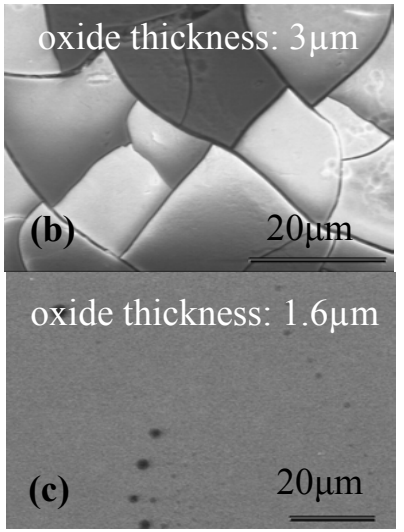
Oxidation Behavior of Silicon Nitride Ceramics and Mixed Alkali Effect

Henry Du, Stevens Institute of Technology, DMR-0102340

Si_3N_4 is an excellent candidate as hot-section components in high-efficiency and high-performance turbine engines. Oxidation resistance is a critical criterion in the design and use of Si_3N_4. We have studied and contrasted the oxidation kinetics and mechanism of three types of Si_3N_4 ceramics with different sintering additives. Turbine-grade SN 282 exhibits the most promising oxidation resistance in dry O_2 due to the protective nature of the oxide formed. TSN-03 is more stable than SN 282, on the other hand, in O_2 containing sodium, a common fuel contaminant, due to the beneficial effect of Al_2O_3 as a sintering additive. Mixed alkali effect is one where co-existence of two dissimilar alkali cations can markedly reduce the detrimental effect of the constituent single alkali cation on many transport-related properties of silica-based materials. Our studies have shown that this effect is absent in oxidation of Si_3N_4 ceramics. This is due to the fact that oxidation of Si_3N_4 in an alkali-containing environment is rate-controlled by interfacial reaction not by diffusion, as revealed in our studies.







(a) Correlation between parabolic rate constants and temperature for oxidation of SN 282, TSN-03 and NBD 200 Si_3N_4 in dry O_2; Surface morphology of (b) SN 282 and (c) TSN-03 oxidized in O_2 with 240 ppm $NaNO_3$ at 1000°C for 20 hours.

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- Education

Participated in by a female doctoral candidate

Hosted one undergraduate summer scholar

- Outreach

Hosted one high-school student in the SEED program (summer experiences for the economically disadvantaged);

Collaborated with Pacific Northwest NL

- Publication and Presentations

(1) M. K. Jordache and H. Du, "Additive-Dependent Oxidation Behavior of Silicon Nitride Ceramics," J. Amer. Ceram. Soc. (in review).

(2) M. K. Jordache and H. Du, "Additive/Impurity Dependent Oxidation of Silicon Nitride," 105th Annual Meeting of the American Ceramic Society, Nashville, TN, April 27-30, 2003.

(3) M. K. Jordache and H. Du, "Mixed Alkali Effect in Oxidation of Silicon Nitride Ceramics," 105th Annual Meeting of the American Ceramic Society, Nashville, TN, April 27-30, 2003.